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THE FUNCTION OF THE LABORATORY IN ENGINEERING CONSTRUCTION

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THE FUNCTION OF THE LABORATORY IN ENGINEERING CONSTRUCTION

George H. Nelson[1]

The function of the laboratory in engineering construction can be divided into two broad categories, first, Design and Development and second, Control and Inspection.

All construction has proceeded from an observation of nature to an idea. The idea grew into a small—then a large scale test. It was further developed and expanded, verified, then used. In this evolution the testing laboratory is certainly the incubator of many ideas and each must be firmly tested and carefully proven before being widely used.

For a moment, let us give some thought to the data on which engineer bases his design. Building design, pavement design, airfield design, dam design, and bridge design all involve certain factors which necessitate in general the consideration of three laboratory procedures.

The first involves knowing the physical or chemical characteristics of the primary materials which we are using. We must know the properties of our structural steel, reinforcing steel, reinforced concrete and our masonry walls. We must have fire tests, acoustical tests, thermal conductivity tests and so on down the list of component parts of our structure. The quality of these materials is extremely important and obviously many of these materials must be controlled within proper limits if we are to use design data without fear.

The second consideration involves tests of combined materials and the structural problems associated with them. The following factors used in design were developed in coordination with actual testing procedures: Compressive and tensile strengths, bond strength, deflection characteristics and stress-strain relationships. There are, of course, many others.

The third consideration is the evaluation of existing conditions, such as the soils at a building site. This involves the use of the new tool, Soil Mechanics. Plate load tests and sub-grade tests of soil have been used for many years in highway and airfield design and to them have been added the engineering knowledge of soil conditions affecting heavy construction. Soil borings have been developed to a fine degree and laboratory testing has become fairly well standardized. Soil mechanics engineers are proving that the soil upon which our structures rest can be treated as an engineering material, that its properties can be measured, its action forecast, and information developed upon which the structural engineer can base his design.

At the present time the functions embracing Design and Development are being carried out by a number of different type organizations. Some of these are College or University Research Programs, College or University Research Institutes, Commercial Research Institutes, Government Laboratories such as the Corps of Engineers and the Bureau of Reclamation, Independent Commercial Testing Laboratories, Independent Civil Engineers, and Group Organizations similar to the American Steel Institute, Portland Cement

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Association, National Sand and Gravel Assn., National Crushed Stone Assn., the National Slag Assn., and our Professional Societies.

Certainly it appears obvious that behind our entire modern conception of design and development the laboratory stands in bold relief, holding a position analogous to that of the chemical laboratory, which has produced our great American chemical industry of today.

The second broad category in which the laboratory functions is Testing and Inspection of materials and Control during construction.

This material quality control involves a considerable amount of testing. A number of items, by no means complete, are tests of structural steel and reinforcing steel at the mill or shop; tests of cement, aggregates, admixtures and design of concrete mixes; tests of asphalt, asphaltic concrete materials and design; routine tests of building materials such as asphalt tile, brick, mortar, roofing materials, dampproofing materials, etc; tests of timber and piles; tests of soils, fill materials and base or sub-base materials. To enumerate a complete list would be like reading the table of contents in the A.S.T.M. Standards. There are over 1500 separate methods and specifications in these standards which include thousands and thousands of detailed tests. If one were interested in knowing the problems which are thrown into the laps of our laboratories around the country the A.S.T.M. Standards would make excellent reading.

I am reminded of my father who read the dictionary constantly. When questioned as to why he read it so much he answered, "It's so interesting because it changes the subject so often." This gives you some idea as to why laboratory work never becomes dull.

In addition to material quality control testing the laboratory finds itself involved with a major job of engineering inspection. While not requiring detail tests, personnel must be able to exercise good sound engineering judgment based upon training and background.

This type of service embraces the inspection of pile driving; control of bases and sub-bases in connection with highway or airfield pavements; control of fill operations for buildings and earth dams; inspection of erection of structural steel framework, including welding inspection and certification of welders; the control or inspection of concrete and asphaltic concrete, mixed in place asphalt or soil-cement operations.

The function of Testing and Inspection and Control is also carried out by various organizations, chiefly among them State Highway Departments, Government Laboratories or Inspectors, Independent Engineering Companies, and Commercial Independent Testing Laboratories.

It is up to these organizations to see that materials are of the proper quality, conform to the specifications, and are placed in the job in accordance with good engineering practice.

Time does not permit the detailing of the many advantages of the laboratory services outlined above. The writer, however, has been intimately connected with the independent testing laboratory for a period of approximately twenty years and would like to point out in some degree the advantages in one of our fields in particular. Similar advantages can be found in all fields and it is believed that the field of concrete design and inspection would be representative. I would therefore like to comment on the advantages of this phase of laboratory services for a few moments.

With the advent of the water-cement ratio theory and scientifically controlled mixing of concrete and the resultant increased allowable stresses used

in design, it has become increasingly necessary to have close control and inspection of concrete for the modern reinforced concrete structure.

The basic quality of ingredients, as well as proportions, used in concrete manufacturing takes on added importance. Years ago, when concrete construction had not reached the mass production stage it has attained today and when costs of materials were several hundred percent lower than today, much carelessness in concrete operations and in material selection could be covered up by the use of extra rich mixtures. Today such operations could not exist. Due to experience with concrete over the years and with the tremendously valuable contributions made by our concrete research and testing engineers, it has been possible to stream-line concrete construction and to pin point and eliminate unnecessary cost items, one of which was excessive overdesign.

Through the selective use of quality materials and by setting up proper laboratory controls, a more economical and better structure can be built with safety today.

The Laboratory's function is to provide adequate technically trained personnel and testing equipment for use so that proper quality tests of materials may be promptly made and so that the proper mixture can be assured through adequate inspection of mixing operations. The laboratory renders a professional service whose purpose is to perform necessary and specified tests and inspections to assure the architect, engineer and contractor that the resulting product is of the quality specified for the owner.

Proper preliminary quality tests of proposed materials will greatly assist the contractor in selecting the most economical combination. Followed by proper mix design in the laboratory with sufficient confirming strength test results, the contractor has basic data on which he can reliably forecast his job performance.

In the old days when concrete was made from fixed arbitrary proportions, it was generally considered that the extra cement required for the volumetric mixtures specified would adequately protect the job from all harm. Research and exhaustive laboratory and field investigations soon focused attention on other important considerations such as workability, durability, and early strength gaining for quicker form removal. New methods of mix designing made it possible to reduce costs by eliminating unnecessary cement and to design for the strength and quality considered necessary for each project.

Tremendously important contributions to the industry have been made by the research laboratories and field engineers of such organizations as the Portland Cement Association, various committee members of the American Concrete Institute and many private laboratories. But the basic starting point for all investigations has been in the laboratory. Coincident with the investigative programs being carried out on the resulting product and its performance under varying conditions, has been an equally important series of test programs conducted on the basic ingredients of concrete—cement, aggregates, air-entraining agents, etc. The objective of all these efforts has been to make a better concrete more economically and thus satisfy the great, growing demands of an expanding economy in this country.

In addition to the important work carried out in research laboratories, much progress has been made in the field through standardizing procedures used by inspection laboratories in order that tests made will better reflect the true condition of the structure. The extension of laboratory services into the field has been a logical progressive forward step.

By making preliminary examination of materials and designing mixtures from them, the laboratory found itself with information which it could very well put into use on the job. This is important. The best of designed mixtures is no good if it is not properly used. Laboratory personnel, trained in the fundamentals of concrete control and inspection were the logical ones to fill this need. They are filling this need.

I would like to point out, however, that the laboratory involved in inspection services is a representative of the architect and engineer who in turn represent the owner, and as such should be employed directly by the architect, engineer or owner rather than by the contractor as is customary in some localities. There are times when this practice of the contractor employing his own laboratory has placed the laboratory in an invidious position. This is not a healthy situation and should merit the consideration of all engineers in this Civil Engineering organization. In the near future a committee of the N.S.P.E. and the A.I.A. are planning to make a study of this problem and attempt to standardize this procedure.

Recognized independent laboratories, under the supervision of registered professional engineers, have developed specialized engineering services which are of great value to the architect, engineer, owner and contractor. They have banded together into an organization known as the American Council of Commercial Laboratories, which has the same high ideals and goals for which the American Society of Civil Engineers stands.

The A C C L is attempting to elevate the standards of our profession and among other things attempting to remove the practice of competitive bidding for professional services. The roster of this Council of 68 leading independent laboratories can be relied on for the procurement of the finest services available.

When considering the employment of a laboratory or any other professional service it might be well to consider the words of wise old John Ruskin, whose words were called to my attention sometime ago by Mr. A. W. Brust, when he wrote - - - - "It's unwise to pay too much, but it's unwise to pay too little. When you pay too much you lose a little money, that is all. When you pay too little, you sometimes lose everything, because the thing you bought was incapable of doing the thing you bought it to do. The common law of business prohibits paying a little and getting a lot. It can't be done. If you deal with the lowest bidder, it's well to add something for the risk you run. And if you do that, you will have enough to pay for something better."

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The technical papers published in the past twelve months are presented below. Technical-division sponsorship is indicated by an abbreviation at the end of each Separate Number, the symbols referring to: Air Transport (AT), City Planning (CP), Construction (CO), Engineering Mechanics (EM), Highway (HW), Hydraulics (HY), Irrigation and Drainage (IR), Power (PO), Sanitary Engineering (SA), Soil Mechanics and Foundations (SM), Structural (ST), Surveying and Mapping (SU), and Waterways (WW) divisions. For titles and order coupons, refer to the appropriate issue of "Civil Engineering" or write for a cumulative price list.

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a. Beginning with "Proceedings-Separate No. 200," published in July, 1953, the papers were printed by the photo-offset method.
b. Presented at the Miami Beach (Fla.) Convention of the Society in June, 1953.
c. Presented at the New York (N.Y.) Convention of the Society in October, 1953.
d. Beginning with "Proceedings-Separate No. 290," published in October, 1953, an automatic distribution of papers was inaugurated, as outlined in "Civil Engineering," June, 1953, page 66.
e. Discussion of several papers, grouped by divisions.
f. Presented at the Atlanta (Ga.) Convention of the Society in February, 1954.

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